ON THE OCCURRENCE OF *SPOROLITHON PTYCHOIDES* HEYDRICH (CORALLINALES, SPOROLITHACEAE, RHODOPHYTA) IN THE MEDITERRANEAN SEA.

Giuseppina ALONGI, Mario CORMACI and Giovanni FURNARI

Dipartimento di Botanica dell'Università. Via A. Longo 19, 95125 Catania, Italy.

ABSTRACT — The occurrence of *Sporolithon ptychoides* in the Mediterranean Sea is first reported. Comparisons with *S. mediterraneum* and *S. molle*, the only two other species of the genus reported from the Mediterranean Sea, have shown that the former is likely to be conspecific of *S. ptychoides*, while the latter has not been verified to occur in that Sea.

RÉSUMÉ — La présence de *Sporolithon ptychoides* est signalée pour la première fois en mer Méditerranée. La comparaison de cette espèce avec *S. mediterraneum* et *S. molle*, les seules autres espèces du genre connues de Méditerranée, a montré que *S. mediterraneum* est probablement conspécifique avec *S. ptychoides*, tandis que la présence de *S. molle* n'est pas démontrée dans cette mer. (Traduit par la Rédaction)

KEY WORDS: Corallinaceae, Mediterranean Sea, Sporolithaceae, *Sporolithon mediterraneum*, *S. molle*, *S. ptychoides*.

INTRODUCTION

The taxonomic position of the genus *Sporolithon* Heydrich, within the order Corallinales has, for a long time, been quite controversial (Johansen, 1969; Womersley & Bailey, 1970; Cabioch, 1971, 1972; Adey *et al.*, 1982). Recently it has been placed in the new family Sporolithaceae by Verheij (1993). According to Verheij (1993), this family is mainly characterized by: i. cells of adjacent filaments connected by both cell fusions and secondary pit connections; ii. tetrasporangia, not in conceptacles, but formed between filaments, on one or more stalk cells, showing apical plugs at their apices and cleaving simultaneously into cruciately arranged spores. This circumscription was analysed and modified by Townsend *et al.* (1995) who concluded that "...the Sporolithaceae is best characterised by tetrasporangia that produce cruciately arranged spores and develop within calcified sporangial compartments". Although, suggesting to not use the occurrence of conceptacle or sorus in family delimitation, Townsend *et al.* (1995) opted for the use of the term sorus to indicate tetrasporangial regions in species of Sporolithaceae "...because, unlike a conceptacle, each region is irregular in shape

and indefinite in size, and because any '*chambers*' present are produced in a haphazard and erratic manner".

Within the genus, the circumscription of only five species was recently made clear: *S. ptychoides* Heydrich and *S. episporum* (Howe) Dawson, by Keats & Chamberlain (1993) and Verheij (1993); *S. episoredion* (Adey, Townsend *et* Boykins) Verheij, by Verheij (1992; 1993); *S. molle* (Heydrich) Heydrich, by Verheij (1993); *S. durum* (Foslie) Townsend *et* Woelkerling, by Townsend *et al.* (1995). According to the above authors, species are mainly distinguished on the basis of characters dealing with tetrasporangial sori, viz.: i. size of tetrasporangia; ii. number of cells in paraphyses between tetrasporangia; iii. occurrence or not of a layer of elongate cells at the base of tetrasporangia; iv. number of additional horizontal layers of cells in between tetrasporangia; v. the fate of tetrasporangia which, after the mature spores are released, can flake off or be overgrown by the thallus (in the latter case, they can be empty or filled by a short filament).

To date, only two species of *Sporolithon* have been recorded from the Mediterranean Sea: i. *S. mediterraneum* Heydrich by Heydrich (1899), Lemoine (1939) [as *Archeolithothamnion mediterraneum* (Heydrich) Foslie], Hamel & Lemoine (1953) (as *Archeolithothamnion mediterraneum*), Giaccone *et al.* (1985); ii. *S. molle* by Di Geronimo & Giaccone (1994).

During our study on Mediterranean algal flora, fertile specimens of a species of *Sporolithon* were collected. In the present paper, results of the study of these specimens as well as of the comparison with Mediterranean records and collections of the other above mentioned species, are reported.

MATERIAL AND METHODS

The study was carried out on both dried and liquid preserved specimens. For microscopic observations, selected fragments were completely decalcified in 0.6 M HNO_3, stained in 4% aqueous $KMnO_4$ for 30-60 minutes, rinsed with water and dehydrated through a series of 30, 60, 90 and 100% ethanol prior to embedding in medium grade "LR White" resin according to the method of Penrose (1991). Serial sections, 6-10 μm thick, were made using a sledge microtome. The sections were placed on a slide with a drop of Canada balsam.

Specimens examined.

Archeolithothamnion mediterraneum (Heydrich) Foslie. Croisière du Pourquoi-Pas 1923, Station 305, Sud des Baléares, -65 m, M. L. *det.*, Muséum National d'Histoire Naturelle, Herb. Général, Paris (PC).

Sporolithon sp. Island of Vulcano (Aeolian Islands, Italy) 25. iv. 1991, -32 m, tetrasporophyte, CAT 1724.

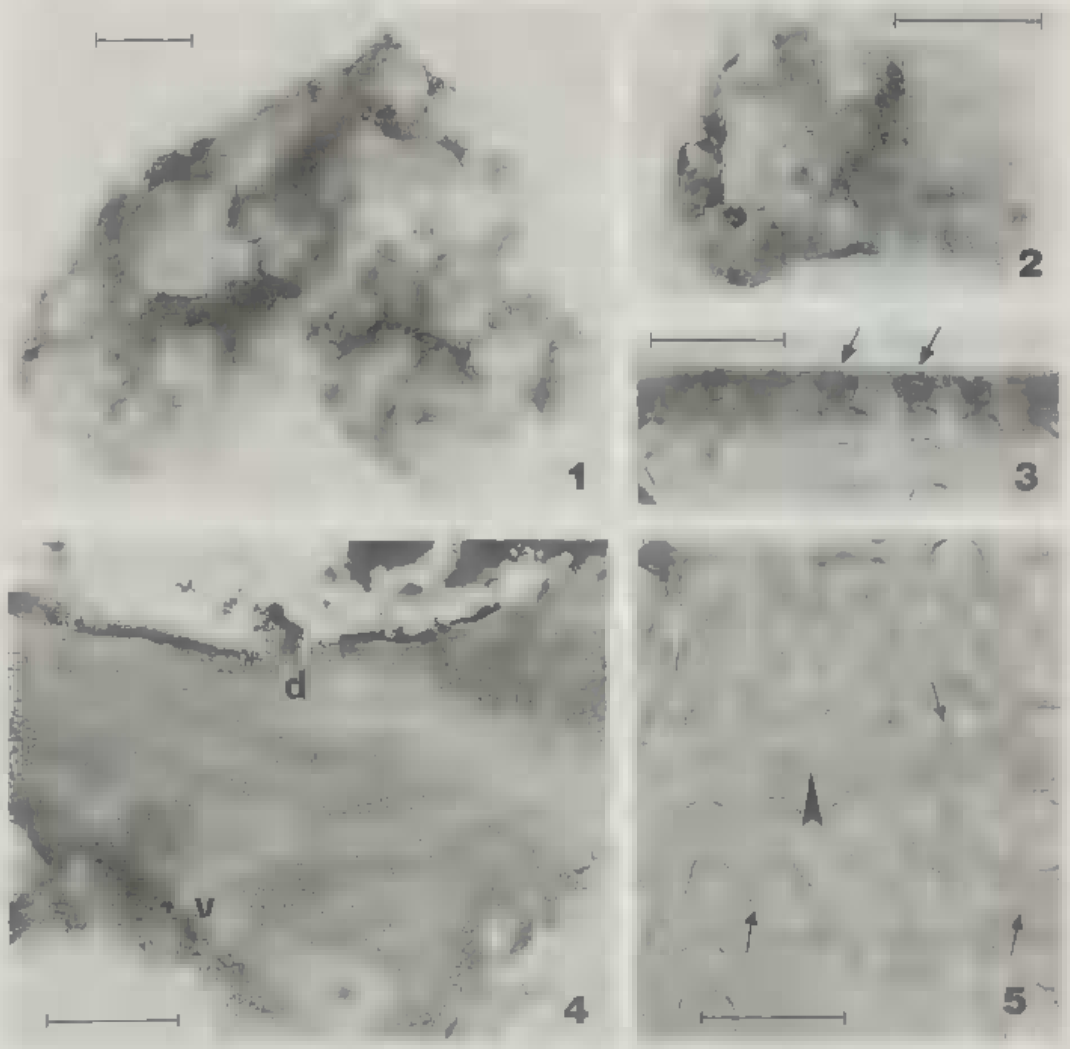
Sporolithon sp. Cannizzaro (Catania, Italy) Nov.1992, -18 m, tetrasporophyte, liquid preserved specimens, CAT 1726.

Sporolithon sp. Island of Comino (Malta) 12. ix. 1994, -20 m, tetrasporophyte, CAT 1725.

Sporolithon sp. Ahrax (Malta) 12. ix. 1994, -1 m, tetrasporophyte, CAT 1727.

OBSERVATIONS AND DISCUSSION

Both Sicilian and Maltese plants are encrusting, flat, warty to lumpy (Figs 1, 2) and partially to completely attached to the substratum. Thalli are pseudoparenchymatous and have crustose parts organized in dorsiventral manner with monomerous construction (Fig. 4). Ventral regions are composed of filaments that form a core running more or less parallel to the substratum; dorsal regions are composed of portions of filaments, with cells squarish to elongate (8-12 x 10-15 µm), curving



Figs 1 — 5. *S. ptychoides*. Fig. 1. Habit of the specimen from the Island of Vulcano. Bar = 0.5 cm . Fig. 2. Habit of the specimen from the Island of Comino. Bar = 0.5 cm. Fig. 3. Transverse section of dorsal region of a thallus showing a single layer of flared epithallial cells (arrows). Bar = 20 µm. Fig. 4. Transverse section showing monomerous construction of the thallus: v = ventral region; d = dorsal region. Bar = 100 µm. Fig. 5. Transverse section of dorsal region of a thallus showing both secondary pit connections (arrows) and cell fusions (arrowhead). Bar = 20 µm.

outwardly from the ventral region towards the surface (Fig. 4). Each filament ends with a single epithallial cell 4-6 µm long and 10-12 µm in diameter with a flared outer wall (Fig. 3). Protuberances of thalli show a radial organization of filaments with monomerous construction.

Cells of adjacent filaments are connected laterally by both cell fusions and secondary pit connections (Fig. 5).

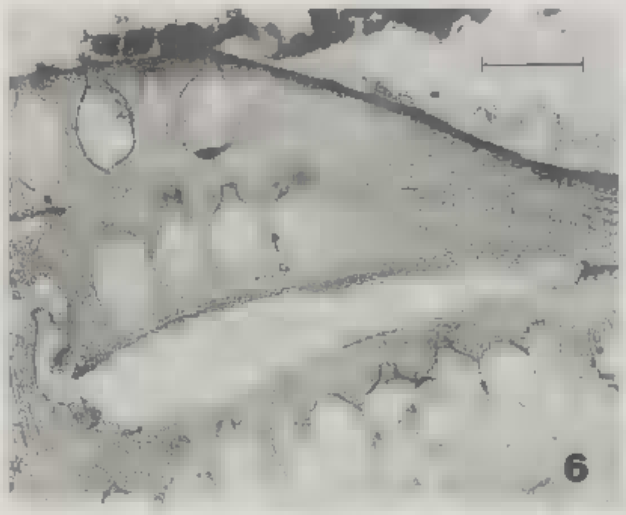
Tetrasporangia, 85-130 x 40-60 µm, are grouped into sori of irregular shape and indefinite size which in a section parallel to the surface appear in a concentric arrangement. 1-2 additional horizontal layers of cells occur in between the tetrasporangia (Fig. 6). Tetrasporangia show cruciately arranged spores (Fig. 7) and are formed on top of a basal layer of elongated cells (Figs 7, 8). The sporangial pore diameter is 12-15 µm. The paraphyses between the tetrasporangia are 4-6 cells long (Fig. 8). Old and empty tetrasporangia become buried (Fig. 6) and, often, are filled by a short filament formed by secondary meristematic activity of the stalk cell.

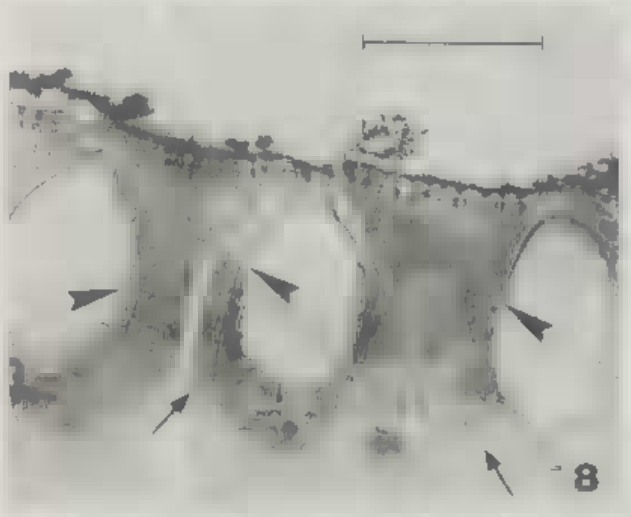
Features observed in our plants correspond to those of *Sporolithon ptychoides* as circumscribed by Verheij (1993) and Keats & Chamberlain (1993). This is the first record from the Mediterranean Sea of this species to date known only from Red Sea, Indian Ocean, Indonesian Archipelago and Hawaiian Archipelago (Verheij, 1993; Ballesteros & Afonso-Carrillo, 1995).

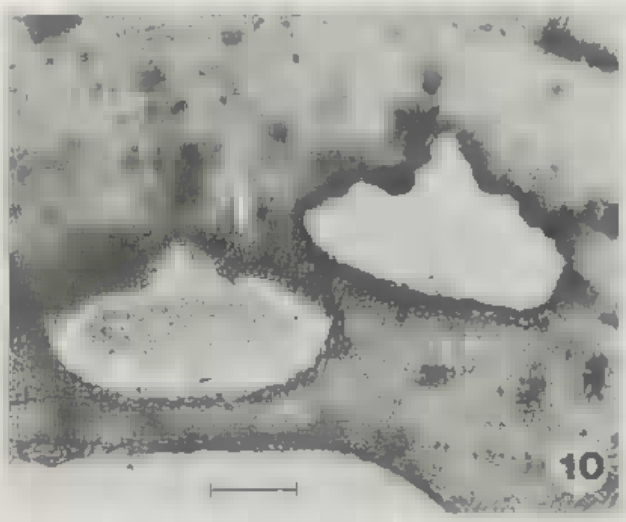
Up to now only *S. molle* and *S. mediterraneum* have been reported from the Mediterranean Sea. *S. molle*, is recorded only from the island of Lampedusa (Pelagean Islands, Italy) by Di Geronimo & Giaccone (1994), but, in that paper insufficient data for identification of the species were reported except the size of tetrasporangia, very small indeed (11-22 x 21-26 µm). Moreover, no Herbarium specimens were kept (Giaccone, pers. comm.). Thus, the record of the occurrence of this species in the Mediterranean Sea cannot be verified, and therefore should be excluded.

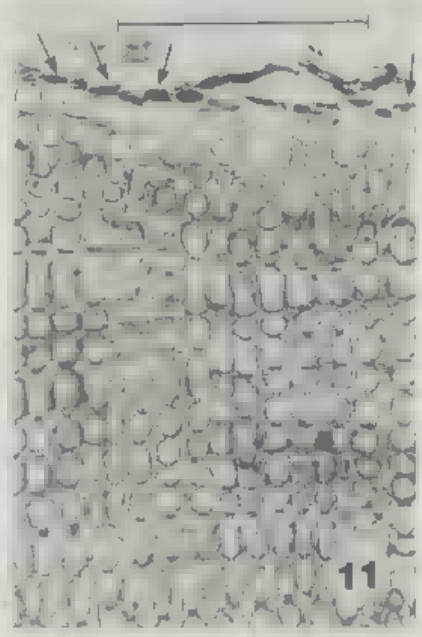
S. mediterraneum was described by Heydrich (1899) from a specimen he thought had been collected by Dr Francotte in the Gulf of Naples (Italy). But, as reported by Lemoine (1939), the specimen had been collected by Dr Schleicher in the Gulf of Villefranche (France). Unfortunately, this specimen has been lost (Hamel & Lemoine, 1953). Lemoine (1939) and Hamel & Lemoine (1953) described, as *Archeolithothamnion mediterraneum* (Heydrich) Foslie (= *S. mediterraneum*), a specimen from the Balearic Islands (Spain). But, the specimen held in the Muséum National d'Histoire Naturelle, Herb. Général, Paris (PC), labelled as "*Archeolithothamnion mediterraneum* (Heydrich) Foslie, Croisière du Pourquoi -Pas 1923, Station 305, Sud des Baléares, — 65 m, M. L. *det.*", does not correspond in the habit (Fig. 9) to the

Figs 6-11. Figs 6-8. *S. ptychoides*. Fig. 6. Transverse section of a thallus showing both sterile and fertile areas. Bar = 100 µm. Fig. 7. Detail of a tetrasporangium: arrowhead indicates the pit connection between the stalk cell and the tetrasporangium; arrow indicates the basal layer of elongated cells; the cruciate division of the tetrasporangium is also detectable. Since the sporangium is sectioned obliquely, the upper spores (which also are broken by a curved crack) appear bigger than the lower spores. Bar = 20 µm. Fig. 8. Detail of a tetrasporangial sorus showing paraphyses (arrowheads) between empty tetrasporangia and the basal layer of elongated cells (arrows) Bar = 100 µm. Figs 9 — 11. Specimen held in the Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris (PC), Herbier Général, labelled as *Archeolithothamnion mediterraneum*. Fig. 9. Habit. Bar = 1 cm. Fig. 10. Transverse section of thallus showing two undefined (if sexual or asexual) conceptacles. Bar = 100 µm. Fig. 11. Transverse section showing the lithophylloid structure. Arrows indicate non-flared epithallial cells. Bar = 100 µm.









specimen illustrated in the fig. 1 published by Lemoine (1939: 342). According to our observations, it shows only secondary pit connections between cells of contiguous filaments, empty uniporate conceptacles (Fig. 10) and a lithophylloid structure with non-flared epithallial cells (Fig. 11). Although neither the occurrence of only secondary pit connections [cell fusions are lacking in *S. episporum* from Natal (Keats & Chamberlain, 1993)] nor the occurrence of uniporate conceptacles [which could be sexual conceptacles of *Sporolithon* (Verheij, 1992; Townsend *et al.*, 1995)] exclude this specimen from *Sporolithon*, the lithophylloid structure and the non-flared epithallial cells, characteristic of the genus *Lithophyllum* (Chamberlain & Irvine *in* Irvine & Chamberlain, 1994) [they are flared in *Sporolithon* spp. (Verheij, 1992, 1993; Keats & Chamberlain, 1993; Townsend *et al.*, 1995)] provide strong evidence that it should be referred to as *Lithophyllum* sp.

Moreover, no observations could be made on plants identified as *S. mediterraneum* from Ustica Island (Italy) by Giaccone *et al.* (1985), since the specimens probably were lost (Giaccone, pers. comm.).

According to Heydrich (1899), *S. mediterraneum* differs from *S. ptychoides* mainly in the tetrasporangia sizes (65 x 120 µm in the former, 40 x 100 µm in the latter). According to Dawson (1960), who provided a preliminary working key (by himself considered very imperfect indeed) to the living species of *Sporolithon* (not including, however, *S. ptychoides*), *S. mediterraneum* is characterized mainly by "protuberances mostly 4-6 mm in diameter". But, it should be pointed out that: i. that key is based mainly on characters relating to external form and that such characters have been shown to be unreliable (Verheij, 1993); ii. the tetrasporangia sizes of *S. mediterraneum* fall within the range of tetrasporangia sizes of *S. ptychoides*: 85-105 x 35-45 µm; 77-108 x 29-53 µm; 85-130 x 40-60 µm, reported by Verheji (1993), Keats & Chamberlain (1993) and observed in our specimens, respectively. Thus it is likely that the two taxa are conspecific, *S. mediterraneum* being a later synonym of *S. ptychoides*. Consequently, *S. ptychoides* seems to be the only living species of this genus in the Mediterranean Sea.

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